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Research Article
Coptotermes curvignathus Holmgren (Isoptera: Rhinotermitidae) Capability to Maintain the Temperature Inside its Nests

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Abstract

Background and Objective: One of the external factor which influence the survival of termites is temperature. Termites try to maintain the temperature inside the nest within a certain range in order to survive. The objective of this research is to analyze the temperature inside nests of subterranean termite *Coptotermes curvignathus*. **Methodology:** This study was conducted at the Termite Rearing Unit, Faculty of Forestry, Bogor Agricultural University. Temperature inside the nest of *C. curvignathus* and indoor temperature in the laboratory were simultaneously measured using thermocouples. Data analysis was based on sinusoidal equation model. **Results:** The results showed that average temperature in the nest was 31.4°C which was 1.3°C warmer than indoor temperature in the laboratory. The data showed that temperature range in termite nest were narrower than indoor temperature range in the laboratory. It was determined based on value of the amplitude which represent the maximum and minimum temperature. **Conclusion:** Termites can maintain the temperature inside the nest so it become less fluctuating than its surrounding.

Key words: Ambient temperature, insulating capability, temperature range, termite nest, sinusoidal equation

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Indonesia is located at 95°-141° East longitude and 6°-11° South latitude. As a tropical country, Indonesia is characterized by high temperatures and humidity throughout the year, with the lowest temperature[1] being 18°C. Bogor is a city located in West Java with an average minimum altitude of 190 m and maximum 330 m a.s.l. This city has warm climatic conditions with annual average temperatures between 25.1-26.4°C and humidity[2] of about 92% making it a nice place for termite to live.

The subterranean termite *Coptotermes curvignathus* have a high intensity of attacks in Indonesia[3]. This termite can make secondary nests high in buildings. Rilatupa[4] reported that this termite is capable to attack apartments and hotels in Jakarta-Indonesia up to the 33rd floor. In addition, this termite can attack living trees and these attacks can lead to the death of the tree[5].

Weather elements such as temperature, humidity and solar radiation affect the behavior of termites. Arinana *et al.*[6] reported that the termite diversity in South Jakarta-Indonesia, was influenced by humidity and sunray radiation, while air temperature was not significantly affected because the air temperature was already suitable for termite life. According to Harris[7], termites are able to maintain physical conditions in their nest so the temperatures inside and outside of the nest will be different. It is important to understand the characteristics of the subterranean termite nest, in order to develop the better plan to avoid the termite's attacks to the urban environment. Therefore, it is necessary to investigate the optimum temperature for *C. curvignathus* nests located in Bogor to hopefully develop an action plant to prevent termite attack to houses or buildings and the environment.

MATERIALS AND METHODS

This study was conducted at the Termite Laboratory, Faculty of Forestry, Bogor Agricultural University in a facility used for rearing *C. curvignathus*, during August, 2014. The temperature was measured in one of the termite nest rearing stations with a size of 150×100×100 cm as well as inside of the laboratory room where nest was located. The tools were small-sized thermocouples that can be placed into termite nests and a multimeter as the temperature reader. Microsoft Excel was used as a data processing software. Clock or timers were also used for the times observation. Temperature measurements were carried out for 3×24 h periods and the temperature recorded every hour. The first observations were conducted at 18.00 pm. The thermocouple was laid in the rearing chambers filled with termites.

Data analysis was based on a model sinusoidal equation developed by Bahtiar *et al.*[8,9] to fit the daily temperature cycle inside the termite nest and indoor temperature in the laboratory. The following model was chosen:

$$y = a + b\sin\left(\frac{\pi}{12}(t - t_0 - k_1)\right) + cz\sin\left(\frac{\pi}{12}(t - t_0 - k_2)\right)$$

Where:

- y = Temperature (°C)
- a, b, c = Regression coefficient
- z = Dummy variable (binary variable which the value is 0 at night and 1 at daytime)
- t = Time of measurement (h) (GMT+7)
- t_0 = Sunrise (h) (GMT+7)
- k_1 = Additional phase for earth's surface energy effects (h) (GMT+7)
- k_2 = Additional phase for sunrays radiation effects (h) (GMT+7)

RESULTS AND DISCUSSION

The result of this study showed that the temperature inside of a nest on the first day ranged from 29.6-33.8°C, on second day 29.9-33.1°C and third day 29.4-33.2°C. While, the temperature outside of the nest (indoor temperature in the laboratory) provided the following ranges 27.5-33.2, 28.2-32.1 and 28.2-32.1°C, respectively (Table 1). Based on the temperature values in Table 1, changes inside the nest were lower than outside. In this case, temperatures in nest ranged from 29.4-33.8°C (changes 4.4°C). While, the temperature outside of the nest ranged from 27.5-32.2°C (changes 5.7°C). It means, termites can maintain the temperature inside the nest become more stable than its surrounding. Generally, temperature inside the nest was warmer than outside. Lee and Wood[10] said that diurnal temperature on the nest

Table 1: Temperature inside and outside of nest *Coptotermes curvignathus*

	Temperature ranges (°C)	
Observation time (day)	Inside nest	Outside nest
1	29.6-33.8	27.5-33.2
2	29.9-33.1	28.2-32.1
3	29.4-33.2	28.2-32.1

of termites varied daily but the temperature in the nest was higher than the soil or environment temperatures. Noirot[11] also stated that the temperature was higher outside the nest (environment) than the area where termites resided.

Fluctuations in the temperature inside termite nests tend to follow fluctuations of the outside temperature. Termite nest temperature observations on the first day showed that temperatures reached their lowest at 06:00 and reach their maximum at 14:00. On the second day temperatures reached their lowest at 07:00 and reached the maximum at 14:00. Meanwhile, on the third day temperatures reached their lowest at 05:00 and reached the maximum temperature at 14:00. The minimum temperature were generally reached in a minute before the sunrise while, the maximum temperature were reached 2 h after midday. Temperature fluctuations inside and outside the termite nests are shown in Fig. 1. These fluctuations are caused by solar radiation and earth-surface energy which can be analyzed by sinusoidal equation developed by Bahtiar *et al.*[8,9]. The sinusoidal equation consider the effect of both sunrays radiation and earth surface energy on the daily cycles of air temperature and relative humidity.

Temperature differences in termite nests by day and hour can be caused by activity, the number of individuals in the colony, the heat generated by the food collected by the termites[12], termite metabolism[11] and the friction that occurs when the termites feed on the wood. In addition, Nandika *et al.*[12] stated that one way to maintain the termite nest temperature is thermoregulation so the temperatures in some parts of the nest may be different but still can be controlled by termites.

Based on the sinusoidal equation models[8,9], two equations were obtained that describe the average temperatures and temperature fluctuations inside and outside the nest. The equations were:

$$\text{Inside nest: } y = 31.3697 + 1.49492\sin\left(\frac{\pi}{12}(t-6-3)\right) - 0.50917z\sin\left(\frac{\pi}{12}(t-6-9.3)\right)$$

$$\text{Outside nest: } y = 30.1487 + 1.82938\sin\left(\frac{\pi}{12}(t-6-2.9)\right) - 0.02397z\sin\left(\frac{\pi}{12}(t-6-1.2)\right)$$

Based on these two models it can be seen that the average temperature of the termite nest is approximately 1.3°C higher than the temperature outside the nest, which can be seen from the value of the regression coefficient (a) in the equation, where the average temperature of the termite nest is 31.4°C, while the temperature outside the nest is 30.1°C.

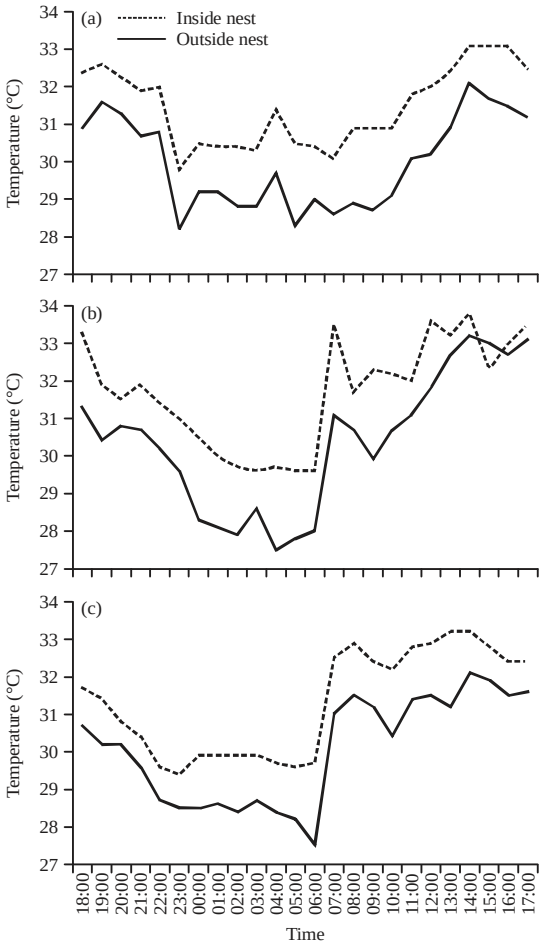

Fig. 1(a-c): Temperature fluctuations inside and outside of termites nest at (a) First day, (b) Second day and (c) Third day

Since, the a value is higher, It is stated that the temperature inside the termite nest is warmer than outside the termite nest. Woodrow and Grace[13] showed that the temperature inside the galleries of dry wood termites *Cryptotermes brevis* is 24.33-37.04°C. Meanwhile, Krishna and Weesner[14] reported that the optimum temperature for macrotermes termite nests is 29-32°C.

The fluctuations in temperature can be seen in the summed amplitude value of b and c. The amplitude value inside the nest is smaller than outside the nest. The mean amplitude value inside the nest was 0.98575 (from 1.49492+(-0.50917)) and the mean amplitude values outside nest was 1.80533 (from 1.82938+(-0.02397)). Temperature fluctuations measured and estimated inside and outside of the termite nests during 3×24 h observation periods are shown in Fig. 2. Termites are capable to maintain the temperature inside the nest so it become less fluctuating than the

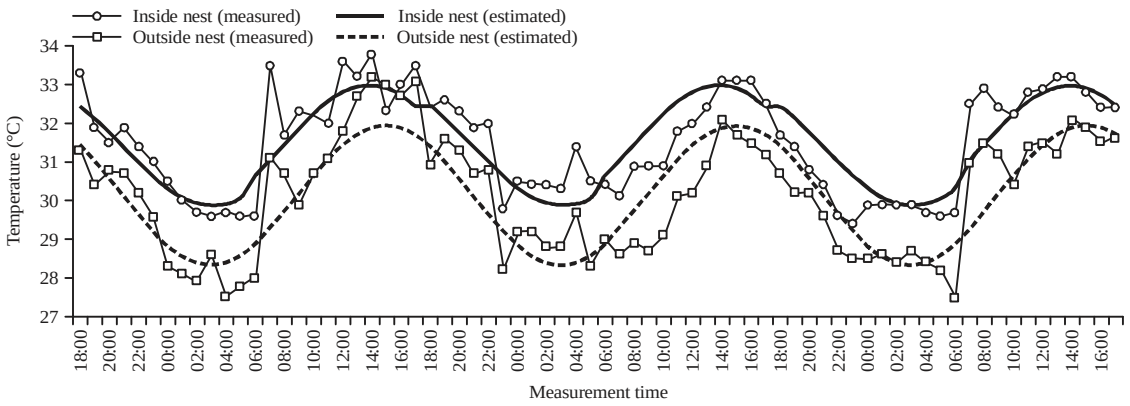

Fig. 2: Temperature fluctuations (measured and estimated) inside and outside termite nests during 3×24 h observation periods

outside temperatures. It showed the insulating capability of subterranean termites nest to ambient temperature.

CONCLUSION

Average temperature in the nest of *Coptotermes curvignathus* was 31.4°C (ranged between 29.4-33.8°C). This nest temperature was 1.3°C warmer than the temperature on the outside surface of the nest or in the laboratory. Nest termite temperatures fluctuate following its surrounding temperature but termites can maintain the temperature inside the nest, so it become warmer and less fluctuating than the surrounding.

SIGNIFICANT STATEMENTS

Coptotermes curvignathus can maintain the temperature inside its nest so it become warmer and less fluctuating than the surrounding.

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